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(54) [Title of the Invention] LIQUID CRYSTAL DISPLAY DEVICE

(57) [Abstract]
[Object] To suppress hillocks of a guard-ring metal film provided in an active

matrix type liquid crystal display device.

[Constitution] An active matrix type liquid crystal display device includes a first substrate 1 including a display region 3 and a peripheral region 4; a second substrate 2 which is provided with a counter electrode and positioned to face the first substrate 1 with a predetermined space therebetween; and a liquid crystal layer held in the space. Pixel electrodes 5 and thin film transistors 6 as switching elements, that drive the pixel electrodes 5, are integrally formed in matrix in the display region 3. In the peripheral region 4, a metal film 7 to serve as a guard ring surrounding the display region 3 is formed. The metal film 7 is formed of a set of segments 9, which are formed by segmentation by slit patterns 8. By segmentation of the metal film 7, film stress is relieved, so that hillocks can be suppressed.

[Scope of Claims]

[Claim 1] A liquid crystal display device including a first substrate including a display region and a peripheral region; a second substrate provided with a counter electrode and positioned to face the first substrate with a predetermined space therebetween; and a liquid crystal layer held in the space, characterized in that

pixel electrodes and switching elements, which drive the pixel electrodes, are integrally formed in matrix in the display region;

a metal film to serve as a guard ring surrounding the display region is formed in the peripheral region; and

the metal film is formed of a set of segments, which are formed by segmentation by slit patterns.

[Claim 2] The liquid crystal display device according to claim 1, characterized in that the metal film is segmentalized into segments each of which has a width dimension of 1 mm or less.

[Claim 3] The liquid crystal display device according to claim 1, characterized in that the metal film is segmentalized into segments each of which has a width dimension of 0.6 mm or less.

[Claim 4] The liquid crystal display device according to claim 1, characterized in that the metal film is formed of aluminum.

[Claim 5] The liquid crystal display device according to claim 1, characterized in that the metal film includes a frame pattern for blocking light along a boundary with the display region.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention] The present invention relates to an active matrix type liquid crystal display device, in which a plurality of pixel electrodes each including a switching element are provided in matrix. In more detail, the present invention relates

to a guard-ring structure for surrounding a display region.

[0002]

[Conventional Art] In order to clarify the background of the present invention, a structure of a conventional active matrix type liquid crystal display device will be briefly described with reference to FIG. 4. As shown in the drawing, a thin film transistor (TFT) 101 is formed as a switching element for driving a pixel, over a glass substrate 100. In addition, a gate line 102 for supplying a selection signal to the TFT 101, a signal line 103 for supplying an image signal thereto, a pixel electrode 104, and the like are formed. Further, a metal film 105 to serve as a guard ring is formed so as to surround a display region including the TFT 101 and the pixel electrode 104. A counter substrate 106 is bonded to this glass substrate 100 with a sealant 107 with a predetermined space therebetween. A counter electrode 108 is formed on an internal surface of the counter substrate 106. A liquid crystal layer 109 is held between the glass substrate 100 on the lower side and the counter substrate 106 on the upper side. The sealant 107 is provided in a peripheral region of the both substrates 100 and 106 in the state where the sealant 107 aligns with the above-described metal film 105.

[0003] FIG. 5 is a planar pattern diagram of the conventional active matrix type liquid crystal display device shown in FIG. 4. As shown in the drawing, the metal film 105 is patterned into a continuous band shape along the peripheral region of the glass substrate 100 and surrounds the display region 110. In the display region 110, as described above, the pixel electrode 104 and the thin film transistor 101 are integrally formed. Further, a vertical drive circuit 111 is formed and connected to each TFT 101 through the gate line 102. A horizontal drive circuit 112 is also formed and connected to each TFT 101 through the signal line 103. Extraction electrodes 113 for external connection are formed on an exposed surface on the upper side of the glass substrate 100. The extraction electrodes 113 intersect with the metal film 105 which is to serve as a guard ring, and each of them is connected to the vertical drive circuit 111 or the horizontal drive circuit 112.

[0004] As is understood from the above description, the metal film 105 surrounds the internal display region 110 and protects the TFT 101 from outside static electricity or the like as a guard ring. In addition, by alignment of the metal film 105 with the sealant 107, wiring steps or the like existing on a surface of the glass substrate 100 are

absorbed so as to planarize the surface, thereby uniforming the thickness of the liquid crystal layer 109. In other words, the guard-ring metal film 105 protects the TFT or the like from an electrostatic damage in the manufacturing process and also has a function of controlling a liquid crystal cell gap to be uniform; accordingly, yield and image quality in display can be improved. Further, this guard-ring metal film 105 functions as a light blocking layer.

[0005]

[Problems to be Solved by the Invention] However, in the case of the above-described conventional structure, there is a problem in that since the guard ring is formed of the continuous band-shaped metal film 105 and has a large area as a whole, a so-called hillock tends to be generated easily due to film stress when heat treatment is applied in a postprocess. This hillock is owing to electromigration or stress migration of a substance that constitutes the metal film 105, and the hillock appears as a projection shape on a metal grain boundary portion. When the hillock is generated, planarity of a surface of the metal film 105 is damaged, thereby fluctuating the thickness of the sealant 107, which could result in defects of a liquid crystal cell gap. Further, the fluctuation may become a cause of liquid crystal leakage from a sealant portion. This hillock sometimes destroys a light blocking property of the metal film 105 and becomes a cause of so-called "light passing". The light passing of the guard ring does not directly affect image quality since the guard ring is apart from the display region including the pixel electrode and the like, but in the case of incorporating a backlight or the like, light passing from the periphery of the display region destroys external quality. This hillock generation becomes a big concern particularly when aluminum is employed as a constituent material of the metal film 105. Metal aluminum tends to generate a hillock easily even with heat treatment at a comparatively low temperature of about 400 °C.

[0006]

[Means to Solve the Problem] In consideration of the above-described problems of Conventional Art, it is an object of the present invention to provide a liquid crystal display device, in which generation of a hillock can be suppressed even when heat treatment is applied to the guard-ring metal film and in which the liquid crystal cell gap defect, the liquid crystal leakage, the generation of light passing, and the like are not

caused. In order to achieve the object, means described blow is carried out. That is, the liquid crystal display device according to the present invention includes as basic constituent elements a first substrate including a display region and a peripheral region, a second substrate provided with a counter electrode and positioned to face the first substrate with a predetermined space therebetween, and a liquid crystal layer held in the space. Pixel electrodes and switching elements, which drive the pixel electrodes, are integrally formed in matrix in the display region. On the other hand, a metal film to serve as a guard ring surrounding the display region, is formed in the peripheral region. A characteristic point of the present invention is that the guard-ring metal film is formed of a set of segments, which are formed by segmentation by slit patterns. Preferably, the metal film is segmentalized into segments each having a width dimension of 1 mm or less. More preferably, the metal film is segmentalized into segments each having a width dimension of 0.6 mm or less. The guard-ring metal film having such a structure is for example formed of aluminum. In addition, the guard-ring metal film has a light blocking frame pattern along a boundary with the display region.

[0007]

[Operation] According to the present invention, slit patterns are formed in the guard-ring metal film, and the metal film is segmentalized into segments each having a width dimension of 1 mm or less for example. Note that the set of segments can conduct electricity as a whole and implements a guard-ring function. When the slit patterns are formed in the guard-ring metal film, continuous area can be reduced and generation of a hillock due to film stress can be suppressed. If a continuous portion of the guard-ring metal film is large, a hillock is easily generated due to film stress in heat treatment in a postprocess. When the area width is longer than 1 mm, considerably high film stress is caused, and a hillock is generated at a high probability. When the area width is limited to 0.6 mm or less, the hillock can be suppressed completely.

[0008]

[Embodiment] Hereinafter, a preferred embodiment of the liquid crystal display device according to the present invention will be described in detail with reference to drawings. FIG. 1 is a planar pattern diagram showing a basic structure of the active matrix type liquid crystal display device according to the present invention. As shown in the drawing, the present liquid crystal display device includes a first substrate 1, a

second substrate 2, and a liquid crystal layer held therebetween. The first substrate 1 includes a display region 3 in the center and a peripheral region 4. Pixel electrodes 5 and thin film transistors (TFTs) 6 as switching elements, which drive the pixel electrodes 5, are integrally formed in matrix in the display region 3. On the other hand, in the peripheral region 4, a metal film 7 serving as a guard ring surrounding the display region 3 is formed. In this embodiment, this metal film 7 is formed of aluminum. The metal film 7 is formed of a set of segments 9, which are formed by segmentation by slit patterns 8. In this embodiment, the slit patterns 8 are formed with linear shapes, and a continuous band of the metal film 7 is segmentalized into two parallel segments 9. Note that the shape of the slit patterns 8 is not limited to the one shown in the drawing. Although the segments 9 are formed by segmentation, they are connected to each other at each corner of the peripheral region 4. Therefore, the segments hold the same level of potential and have a guard-ring function. The width dimensions of the segments 9 are set to be 1 mm or less. If the width dimension is more than 1 mm, film stress is increased and a hillock is generated at a high probability. Note that when the width dimensions of the segments 9 are set to be 0.6 mm or less, a hillock can be prevented completely. In order to do this, for example, the number of the slit patterns 8 may be increased. When the slit patterns 8 are formed, a light blocking property of the metal film 7 is lost. However, the light blocking property is originally required in a range within a certain distance from the display region 3. Even if the slit patterns 8 exist in the outer range, there is no problem. In considering this respect, in the present embodiment, the slit patterns 8 are formed with linear shapes so that a light-blocking frame pattern 10 remains along a boundary with the display region 3. As is apparent from the drawing, this light-blocking frame pattern 10 is formed from the segments 9 positioned on the inner side of the slit patterns 8.

[0009] In the display region 3 surrounded by the guard-ring metal film 7, pixel electrodes 5 are positioned in matrix as described above to form individual liquid crystal pixels. The TFT 6 is connected to each of the pixel electrodes 5. Gate electrodes of the TFTs 6 are connected to gate lines 11, and source electrodes thereof are connected to signal lines 12. A plurality of gate lines 11 are connected to a vertical drive circuit 13, whereas a plurality of signal lines 12 are connected to a horizontal drive circuit 14. The vertical drive circuit 13 line-sequentially selects the TFTs 6 via the gate lines 11,

and the horizontal drive circuit 14 supplies image signals to corresponding pixel electrodes 5 through the selected TFTs 6 via the signal lines 12.

[0010] Extraction electrodes 15 for external connection are formed on an upper end portion of the first substrate 1. The extraction electrodes 15 intersect with the guard-ring metal film 7 and each of them is connected to the vertical drive circuit 13 or the horizontal drive circuit 14. These extraction electrodes 15 are formed of aluminum, similarly to the guard-ring metal film 7. For easy understanding, an enlarged pattern shape of the intersection between the extraction electrode 15 and the guard-ring metal film 7 is shown. As shown in the drawing, the band of the guard-ring metal film 7 is partially removed, and toward this portion, the extraction electrode 15 extends. The separated metal films 7 are connected to each other for example by a polycrystalline silicon film 16, which is patterned into a predetermined shape. This polycrystalline silicon film 16 is for example formed at the same time as the gate lines 11, and insulated from the metal film 7 and the extraction electrode 15 by an interlayer insulating film. This extraction electrode 15 is provided from the vertical drive circuit 13 or the horizontal drive circuit 14 toward the outside of a sealant for electric connection to the outside. Accordingly, a middle portion of this extraction electrode 15 strides over a sealant portion. In the present structure, in the sealant portion, the guard-ring metal film 7 is provided close to both sides of the extraction electrode 15. Accordingly, the entire sealant portion can be mostly planarized. In other words, since the extraction electrode 15 and the guard-ring metal film 7 are formed of aluminum with the same thickness, step difference is eliminated. Note that this portion of the guard-ring metal film 7 is divided in order to make the extraction electrode 15 pass. Since the guard-ring metal film 7 is segmentalized, the slit pattern 8 is not provided particularly. However, in order to suppress a hillock more efficiently, a slit pattern may be surely provided.

[0011] FIG. 2 shows a cross sectional structure of the active matrix type liquid crystal display device shown in FIG. 1. As shown in the drawing, thin film transistors (TFTs) are integrally formed over the first substrate 1 which is formed of glass, quartz, or the like. For easily viewing the drawing, only two TFTs are shown. The TFT 6 on one side is used for switch driving the corresponding pixel electrode 5, and a TFT 17 on the other side forms a drive circuit for performing sequential selecting and driving of a

matrix array of pixel electrodes. Each TFT includes a polycrystalline silicon film 18, which is patterned into a predetermined shape. This polycrystalline silicon film 18 is for example formed with a thickness of 50 nm by an LP-CVD method. Over this polycrystalline silicon film 18, a gate electrode G is formed with a gate insulating film 19 formed of SiO_2 therebetween. The gate electrode G of the TFT 6 is extended from the gate line (not shown). These gate electrode G and gate line are formed at the same time by an LP-CVD method and formed of a polycrystalline silicon film with a thickness of 350 nm, which is doped with an impurity. A first interlayer insulating film 20 is formed thereover to cover the polycrystalline silicon film. The first interlayer insulating film 20 is for example formed of a PSG film with a thickness of 600 nm, which is formed by an AP-CVD method. An aluminum film with a thickness of 600 nm for example is formed thereover by sputtering. This aluminum film is patterned into a predetermined shape, and the signal line 12, wiring electrodes 22, the guard-ring metal film 7, and the like are formed. The signal line 12 is electrically connected to a source region S of the TFT 6 through a contact hole provided in the first interlayer insulating film 20. In addition, similarly to the above, the wiring electrodes 22 are electrically connected to a source region S and a drain region D of the TFT 17 through contact holes provided in the first interlayer insulating film 20. A second interlayer insulating film 23 is formed over the aluminum film. This second interlayer insulating film 23 is for example formed of a PSG film deposited with a thickness of 400 nm by an AP-CVD method. Further, a transparent conductive film formed of ITO or the like is formed thereover with a thickness of 150 nm by sputtering. This transparent conductive film is patterned into a predetermined shape and becomes the pixel electrode 5. The pixel electrode 5 is electrically connected to a drain region D of the TFT 6 through a contact hole provided in the second interlayer insulating film 23 and the first interlayer insulating film 20.

[0012] The second substrate 2 is positioned to face the first substrate 1 with a predetermined space therebetween. This second substrate 2 is bonded to the first substrate 1 with a sealant 24. The sealant 24 is provided so as to align with the guard-ring metal film 7 by screen printing or the like. On an internal surface of the second substrate 2 formed of glass or the like, a black mask 25, which is patterned into a predetermined shape, and a counter electrode 27 attached with an insulating film 26

interposed therebetween are formed. The black mask 25 is formed and patterned so as to block light to the TFT 6 and the TFT 17. A portion other than the pixel electrode 5 is covered with the black mask 25 formed on the second substrate 2 side and the guard-ring metal film 7 formed on the first substrate 1 side; accordingly, a desired light blocking structure can be obtained. Finally, a liquid crystal layer 28 is sealed to be held between the second substrate 2 and the first substrate 1. This liquid crystal layer 28 is for example formed of twist alignment nematic liquid crystal.

[0013] The guard-ring metal film 7, which is a characteristic element of the present invention, is provided so as to surround the display region including the TFTs and the pixel electrodes. As described above, the guard-ring metal film 7 is patterned at the same time as the signal line 12 and the wiring electrodes 22, and they are formed of the same material including aluminum at a thickness of 600 nm. The guard-ring metal film 7 electrically protects the TFTs positioned at the inside and also attempts to planarize an attachment portion in alignment with the sealant 24. The guard-ring metal film 7 is segmentalized by the slit patterns 8. This suppresses migration of aluminum and prevents generation of a hillock. Since the hillock is not generated, there is no fear that the second interlayer insulating film 23 stacked over the metal film 7 is peeled. Accordingly, adhesiveness of the sealant 24 is not lost and leakage of the liquid crystal layer 28 is not caused.

[0014] FIG. 3 is a planar pattern diagram showing a second embodiment of a liquid crystal display device according to the present invention. A basic structure is the same as that of the first embodiment shown in FIG. 1, and corresponding parts are denoted by the corresponding reference numerals for easy understanding. A different point is that the slit patterns 8 formed in the guard-ring metal film 7 have not linear shapes but minute cross shapes, which are regularly arranged. The metal film 7 can be segmentalized by such cross-shaped patterns, and each of the segments 9 has a width dimension of 1 mm or less. If the cross-shaped slit patterns 8 are formed in an entire surface along the band of the guard-ring film 7, light leakage is generated correspondingly. However, light leakage having a regular pattern does not always lose the external appearance and may rather produce an ornament effect. Conversely, if light leakage is generated owing to a randomly generated hillock, the external appearance of the liquid crystal display device is undoubtedly degraded. In the case

where functional light blocking is required, a continuous light-blocking frame pattern may be provided along the boundary with the display region 3 similarly to the first embodiment. Note that the width is preferably set to be 1 mm or less.

[0015] The aluminum film having a thickness of 600 nm is used as the guard-ring metal film in the above-described embodiment; however, the present invention is not limited to this as long as it is sufficiently low-resistant and is the same material as the electrodes for extraction to the outside. The light blocking property of the guard-ring metal film may be such that the transmittance in the visible light region (400 nm ~ 700 nm) is 1 % or less, and preferably 0.1 % or less. As the material, other than aluminum (Al), a metal such as Cr, Ni, Ta, Ti, W, Cu, Mo, Pt, or Pd; an alloy thereof; silicide; or the like can be used. In using every material, it is acceptable as long as the thickness is determined so as to satisfy the predetermined light blocking property, and the thickness is generally 50 nm or more. Further, in the present embodiment, the slit patterns provided in the guard-ring metal film have linear shapes or minute cross shapes; however, the present invention is not limited to this. Generally, it is preferable that the guard-ring metal film can be segmentalized into parts each having a dimension of 1.0 mm or less, and preferably 0.6 mm or less. If the segment width is set to be 1.0 mm or more, the hillock suppression effect is decreased.

[0016] In the present embodiment, polycrystalline silicon is used for the semiconductor layer of the TFTs, the gate electrodes, and the gate lines; SiO_2 is used for the gate insulating film; and aluminum is used for the signal line. However, the present invention is not limited to this. For example, amorphous silicon may also be used for the semiconductor layer of the TFTs. For example, silicide, polycide, or metal such as Ta, Al, or Cr may be used for the gate electrodes and the gate lines. For example, SiN, tantalum oxide, or the like can be used for the gate insulating film. For example, Ta, Cr, Mo, Mi, or the like can be used for the signal lines. In addition, the present invention can surely be applied to an active matrix type liquid crystal display device using any of a planar type, a staggered type, or an inversely staggered type for the thin film transistor.

[0017]

[Effect of the Invention] As described above, according to the present invention, segmentalization with a width dimension of 1 mm or less is tried by provision of slit

patterns in the guard-ring metal film, which surrounds the display region. This segmentalization causes relieving of film stress, so that migration becomes harder to be generated and generation of a hillock is suppressed. This makes it possible to keep planarity of the guard-ring metal film at an interface with the sealant, and generation of a liquid crystal cell gap defect can be prevented. Further, since peeling of the interlayer insulating film, which is stacked over the guard-ring metal film, is not generated, liquid crystal leakage can be prevented. Furthermore, random light passing through the guard-ring metal film, which is caused by the hillock, can be improved and there is no possibility of degrading the external appearance.

[Brief Description of the Drawings]

[FIG. 1] A planar view showing the first embodiment of the active matrix type liquid crystal display device according to the present invention.

[FIG. 2] A cross sectional view of the active matrix type liquid crystal display device shown in FIG. 1.

[FIG. 3] A planar view showing the second embodiment of the active matrix type liquid crystal display device according to the present invention.

[FIG. 4] A cross sectional view showing one example of the conventional active matrix type liquid crystal display device.

[FIG. 5] A planar view showing one example of the conventional active matrix type liquid crystal display device, similar to FIG. 4.

[Explanation of Reference]

1	First substrate
2	Second substrate
3	Display region
4	Peripheral region
5	Pixel electrode
6	Thin film transistor
7	Metal film
8	Slit pattern
9	Segment
10	Light-blocking frame pattern
15	Extraction electrode